## What is claimed is:

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- A cryogenic fuel tank comprising:
   an exterior surface comprising a skin layer; and
- a composite insulation layer affixed to at least a substantial portion of the skin layer, the composite insulating layer including a reinforcing material combined with a non-flammable polymer foam material.
  - 2. The fuel tank of claim 1 wherein the polymer foam material comprises a closed cell foam material.
  - 3. The fuel tank of claim 1 wherein the foam material is polyisocyanurate foam.
- 4. The fuel tank of claim 3 wherein the polyisocyanurate foam is a closed cell foam.
  - 5. The fuel tank of claim 1 wherein the polymer foam material comprises polyurethane foam.
- 20 6. The fuel tank of claim 5 wherein the polyurethane foam is a closed cell foam.
  - 7. The fuel tank of claim 1 wherein the reinforcing material includes at least one sheet of material added to the polymer foam material.
  - 8. The fuel tank of claim 7 wherein the at least one sheet is a mesh grid sheet of fibers embedded within a layer of the polymer foam material.
- 9. The fuel tank of claim 8 wherein the at least one sheet is a mesh grid sheet of aramid fiber material.
  - 10. The fuel tank of claim 9 wherein the at least one sheet is a mesh grid sheet having a plurality of interconnected linear fibers.

- 11. The fuel tank of claim 9 wherein the at least one sheet is a mesh grid having a plurality of interconnected curvilinear fibers.
- 12. The fuel tank of claim 1 wherein the reinforcing material is selected from the group consisting of nanotubes, nanorods, graphite whiskers, graphite epoxy, poly(p-phenylene terephthalamide) aramid fiber, carbon graphite fiber, poly(m-phenylene terephthalamide) fiber, silicone nitride fiber, silicone carbide fiber, polyaramid fiber, gel-spun polyethylene fiber, polyarylate fiber, and poly(phenylene sulfide) fiber.

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- 13. The fuel tank of claim 1 wherein the reinforcing material comprises a plurality of discrete strengthening fibers interspersed and embedded within a layer of the polymer foam material.
- 15 14. The fuel tank of claim 13 wherein the discrete fibers are selected from the group consisting of silicon carbide fibers, nanotubes, nanorods, carbon graphite whiskers and carbon graphite fibers.
  - 15. The fuel tank of claim 14 wherein the discrete fibers are nanotubes.

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- 16. The fuel tank of claim 15 wherein the nanotubes have diameters ranging from about 1 to about 2 nm and lengths ranging from about 0.1  $\mu$ m to about to about 50  $\mu$ m.
- 25 17. The fuel tank of claim 16 wherein the polymer foam material is a closed cell foam having a cell size of about 200 μm.
  - 18. The fuel tank of claim 16 wherein a plurality of the nanotubes intersect and are fused to one or more other nanotubes.

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19. The fuel tank of claim 14 wherein the discrete fibers are carbon graphite whiskers having a diameter ranging from about 0.1 to about 1  $\mu$ m and a length ranging from about 5 to about 50  $\mu$ m.

- 20. The fuel tank of claim 19 wherein the polymer foam material is a closed cell foam having a cell size of about 200 μm.
- The fuel tank of claim 14 wherein the discrete fibers are carbon fibers
   having diameters of less than 8 μm and the polymer foam material is a closed cell foam having a cell size of about 200 μm.
  - 22. A cryogenic fuel tank for attachment to an exterior of an orbiter during launch and ascent, the fuel tank comprising:

a skin layer having an exterior surface; and

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a composite insulation layer affixed to at least a substantial portion of the exterior surface of the skin layer, the composite insulating layer including a reinforcing material embedded with a closed cell polyisocyanurate foam,

the reinforcing material being selected from the group consisting of nanotubes, nanorods, graphite whiskers, silicone carbide fiber, poly(p-phenylene terephthalamide) aramid fiber mesh, and poly(m-phenylene terephthalamide) fiber mesh.

- 23. The fuel tank of claim 22 wherein reinforcing material consists
   20 essentially of the discrete fibers are nanotubes having diameters ranging from about 1 to about 2 nm and lengths ranging from about 0.1 μm to about to about 50 μm and the polyisocyanurate foam is a closed cell foam having a cell size of about 200 μm.
- 24. The fuel tank of claim 23 wherein a plurality of the nanotubes intersect and are fused to one or more other nanotubes.
  - 25. The fuel tank of claim 22 wherein reinforcing material consists essentially of the discrete fibers are carbon graphite whiskers having a diameter ranging from about 0.1 to about 1 μm and a length ranging from about 5 to about 50 μm and the polyisocyanurate foam is a closed cell foam having a cell size of about 200 μm.

- 26. The fuel tank of claim 22 wherein the reinforcing material consists essentially of poly(p-phenylene terephthalamide fiber mesh.
- A method for strengthening an exterior insulation layer on an exteriorsurface of a skin of a cryogenic fuel tank, the method comprising:

providing a quantity of a non-flammable polymer foam material and a reinforcing material;

combining the polymer foam material and the reinforcing material to form a composite insulating layer; and

affixing the composite insulating layer in an uncured state to at least a substantial portion of the exterior surface of the skin.

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- 28. The method of claim 27 wherein the combining further comprises: embedding the reinforcing material in the foam material when the foam 15 material is in a liquid state.
  - 29. The method of claim 28 wherein the embedding further comprises: spraying the exterior surface of the skin of the fuel tank with the foam material to form a first layer of foam material thereon;
- placing at least one sheet of the reinforcing material over the first layer of foam material; and

spraying a second layer of foam material on the sheet and first layer.

- 30. The method of claim 28 wherein embedding further comprises:
  adding a plurality of discrete strengthening fibers to the foam material before
  the foam material is cured and affixed to the exterior surface of the skin.
  - 31. The method of claim 27 wherein the combining and affixing are completed substantially simultaneously.

32. The method of claim 28 further comprising: adding a foam material layer in a liquid state onto the exterior surface of the skin;

placing a reinforcing material layer on the first foam material layer;

adding another foam material layer in a liquid state onto the first foam material and reinforcing material layers; and curing the foam material layers.

- 33. The method of claim 32 wherein the adding further comprise pouring the liquid foam material.
  - 34. The method of claim 32 wherein adding further comprise spraying the liquid foam material.
- 15 35. The method of claim 32 wherein the adding, placing and adding are repeated a desired number of times.
  - 36. The method of claim 27 further comprising:

securing at least one reinforcing material layer adjacent the exterior surface of the skin;

adding a foam material layer in the liquid state in such a manner to substantially encapsulate the reinforcing material layer in the foam material layer; and curing the foam material layer.

- 25 37. The method of claim 36 wherein the adding further comprises: pouring the liquid foam material over the reinforcing material layer and the skin layer.
- 38. The method of claim 37 wherein the adding further comprises:
  spraying the liquid foam layer over the reinforcing material layer and the skin layer.

39. The method of claim 27 wherein the combining further includes adding a sufficient amount of the reinforcing material to a sufficient amount of the polymer foam material so that the composite insulating layer has a compressive strength and a tensile strength sufficient to prevent the composite insulating layer from fracturing and being separated from the fuel tank as a result of thrust imposed on the composite insulating layer during a launch and ascent to space when the fuel tank is attached to a space shuttle orbiter.

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- 40. The method of claim 27 wherein the polymer foam material comprises a closed cell polyisocyanurate foam.
  - 41. The method of claim 40 wherein the reinforcing material is selected from the group consisting of nanotubes, nanorods, graphite whiskers, silicone carbide fiber, poly(*p*-phenylene terephthalamide) aramid fiber mesh, and poly(*m*-phenylene terephthalamide) fiber mesh.
  - 42. The method claim 41 wherein the reinforcing material consists essentially of the discrete fibers are nanotubes having diameters ranging from about 1 to about 2 nm and lengths ranging from about 0.1 μm to about to about 50 μm and the polyisocyanurate foam is a closed cell foam having a cell size of about 200 μm.
  - 43. The method claim 42 wherein a plurality of the nanotubes intersect and are fused to one or more other carbon nanotubes.
- 25 44. The method of claim 41 wherein the reinforcing material consists essentially of discrete fibers are carbon graphite whiskers having a diameter ranging from about 0.1 to about 1 μm and a length ranging from about 5 to about 50 μm and the polyisocyanurate foam is a closed cell foam having a cell size of about 200 μm.

## 45. A space orbiter comprising:

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a skin layer comprising an interior surface; and

a composite insulation layer affixed to at least a substantial portion of the skin layer, the composite insulating layer including a reinforcing material combined with a closed cell polyisocyanurate foam,

the reinforcing material being selected from the group consisting of nanotubes, nanorods, graphite whiskers, silicone carbide fiber, poly(p-phenylene terephthalamide) aramid fiber mesh, and poly(m-phenylene terephthalamide) fiber mesh.